CAMEL FARMING SUSTAINABILITY: THE CHALLENGES OF THE CAMEL FARMING SYSTEM IN THE XXIth CENTURY

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Abstract
The changes of the camel farming passing from traditional way to modern style lead to decrease the apparent sustainability of the camel production throughout the world. The challenges for all camel stakeholders to maintain this image and to promote a "sustainable development" involve the control of the camel demography which must be balanced with the carrying capacity, the preservation of the camel biodiversity, the development of alternative feeding systems for preserving the water resources in desert areas, the promotion of high-value products to the growing market, the control of the health constraints for a highly mobile camel population, and the respect of the social role of camel in the new living standard.
Keywords: camel, sustainable development, farming system

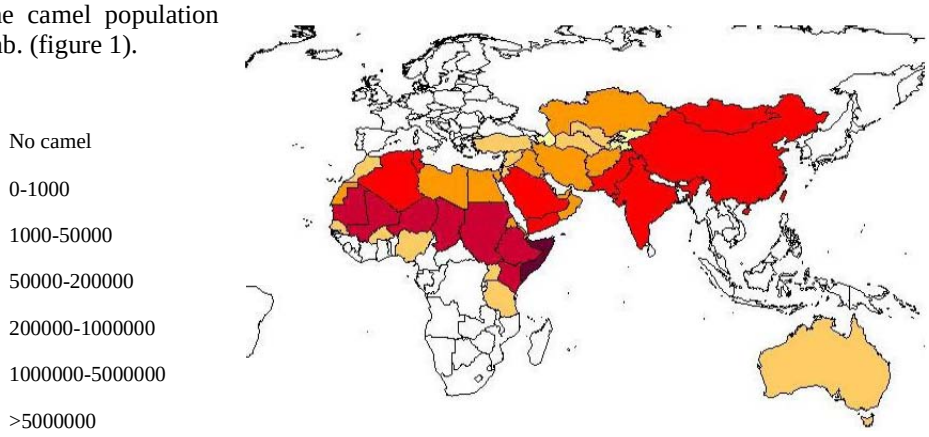
Introduction

The word sustainability was defined by the United Nations as the development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Adams, 2006). The three pillars of sustainability are regarded as the reconciliation of environmental, social equity and economic demands. However, for some environmentalists, the idea of sustainable development is an oxymoron as development seems to entail environmental degradation (Redclift, 2005). Anyway, even if the concept of sustainability could be regarded as a feel-good buzzword with little meaning or substance, it implies responsible and proactive decision-making and innovation that minimizes negative impact and maintains balance between social, environmental, and economic growth to ensure a desirable planet for all species now and in the future. In that context, the camel, the most important animal domesticated by the mankind in desert ecosystem, is faced to important challenges because it is directly confronted to one of the hot-spot regarding the interaction livestock/environment (Steinfeld et al., 1999), i.e. the desertification process. It is currently admitted that the camel being well adapted to such arid environment, it is an environmentally friendship animal and the camel farming system, a low environmental pressure activity (Raziq et al., 2008). Yet, the current changes in the camel farming systems are modifying the traditional relationships between the camel and their environment (Faye et al., 2012). Such evolutions have to be taken in consideration to identify the challenges for a future development of the camel farming worldwide. In the present paper, 5 aspects regarding the camel sustainability are taken in account: (i) the changes in camel demography reflecting the pressure on the environment, (ii) the preservation of the camel biodiversity, (iii) the water and the feeding management of camel in new intensive systems, (iv) the integration of camel rearing in global economy, (v) the social dimension of the camel in the desert societies.

Camel demography, a contrasted report

The ecological footprint is one of the measures to assess the human pressure on the environment. For livestock, the ecological footprint could be appreciated by its carrying capacity, i.e. the ratio between the whole population and the available resources (water, feeding, land) for maintaining the livestock production. Regarding the camel demography, the number of heads increased regularly since 1961, but the present estimated world population by FAO (24,681,000 in 2010) was under the sum of national estimations (27,083,000) and not included Australian population (1 to 1.5 million heads- Ward and Burrows, 2010). In 2010, the camel population was still mainly concentrated in the Horn of Africa and in Sahelian countries (map 1). The camel population in 2010 was slightly more than double than in 1961 (it was multiplied by 2.04), corresponding to annual growth of 2.1%. By comparing this annual growth to other species at world level, the camel population was growing faster than cattle (multiplied by 1.46), sheep (1.08), horse (0.95) and lama (1.48) and was close to buffalo population growth (2.12), but lower than goat population growth (2.52).
However, the annual growth is quite variable from one country to another (from -2.1% in former soviet republics to 13% in Somalia). Overall, the pattern of the annual growth since 49 years allows identifying 5 types of countries described as follow: (i) The countries with a **regular camel population growing** mainly based in the Horn of Africa and Near-East; (ii) The countries with a **recent but important growing** of their camel population, mainly in Western Africa and Arab Peninsula; (iii) The countries with a **stable population** (Kuwait, Lebanon, Libya and Senegal); (iv) The countries with **regular declining camel population** (mainly in Central Asia, China and India); (v) The countries with **severe decline** (Iraq, Turkey, northern part of Morocco)

The decline of the camel population is not correlated to the development level of the country. Indeed, there is no correlation between the camel population growth and the GDP/hab. (figure 1).



Map 1. Distribution of the camel population in the world in 2010 (source: Faye and Bonnet, 2012)

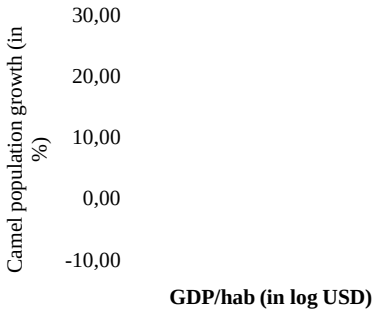


Figure 1. Relationships between camel population growth and GDP/hab in 2010

The most important aspect regarding camel demography is not only the growth of the number of heads, but also, the relative importance of camels in the total livestock of the "camel countries". This ration could be estimated by the percentage of Tropical Livestock Units (TLU) due to camel reported to the total TLU of each country. Regarding this aspect, 5 levels of economical importance of camel population could be identified: (i) the countries with marginal importance, the camel population representing less than 2% of the total TLU (South Asia and Near-East mainly), (ii) the countries with low economical importance 2-5% TLU (Egypt, Libya, Central Asia, Pakistan, Iraq,…), (iii) the countries with medium importance (5-10%) as Algeria, Kenya and Ethiopia, (iv) the countries where camel are quite important (10-25%), mainly belonging to Sahelian countries and Arabian Peninsula, (v) the countries where camels represented more than 25% of whole TLU (Mauritania and Somalia).
Another indicator attesting the relative importance of camel population is the camel density. A highest density is observed in the Horn of Africa and Emirates (more than 2 camels/km²) and in Sahelian countries (1 camel/km²). The density is lower in Asia except in Pakistan and Afghanistan. These two indicators (percentage of TLU and density) show that the economical importance of camel is quite predominant in Sub-Saharan countries and the Arabia Peninsula. Thus, the problem of the ecological footprint of the camel stock could appear more acute in those last regions of the world. However, it is the balance between the growth in camel population and the ability to maintain sustainable resource use which must be reached. In that sense, the camel productivity (to increase the production with fewer inputs) must be assessed as it is underlined in the next chapter.

The camel biodiversity, a richness to preserve
Based on the official definition of the term biodiversity, we can regard camel biodiversity as the variability including the totality of genes, breeds and ecotypes of camel worldwide (Benton, 2001). In camel, the selection pressure by human was quite soft compared to other domestic ruminants as cattle, sheep and goat. Contrary for example to dairy cattle where the Holstein-Friesian breed became predominant, or the Saanen breed for dairy goat, the gene exchanges between camels remain marginal. The selection achieved by the breeders in the camel history had only oriented camel phenotypes for special use as packing, racing and more recently to dairy, meat or wool production. Recent molecular genetic studies regarding camel at world level showed that the camel genetic variability is originating from Arabian Peninsula where the camel biodiversity is the most important (Almathen

et al., 2012) and confirmed the origin of all the dromedary camels in Africa and Asia. For example, a high genetic difference was observed between North and West African types in one part, and "breeds" from the Horn of Africa in another part. Thus, these two camel populations are closed to two different camel genotypes from Arabian Peninsula. In Saudi Arabia, 3 main populations were identified, confirmed by phenotypic description (Abdallah and Faye, 2012).

However, the knowledge regarding the camel breed's or type's performances is still low. Regular records of dairy or growth performances according camel breeds in order to create a nucleus for genetic improvement, is quite marginal and generally involves few animals. Clearly, except some activity on racing camel, there was no national selection program in most of the "camel countries". In fact, the camel productivity did not increase sufficiently. For example in Saudi Arabia, during the period 1961-2010, milk and meat productivity increased in similar proportion than the camel population (5.2%/year), i.e. 5.4%/year for milk production and 6.4%/year for meat production. In fact, the increase of milk and meat productivity was mainly linked to the population growth. Regarding the higher meat production growth, it is rather due to the increase of slaughtering rate than to the meat productivity. Indeed, the mean carcass weight is the same in 2010 compared to 1961 (224 kg) and the slaughtering rate increased by 6.6%/year. The dairy productivity did not change also since the last 49 years and the increase of dairy production is linked to the increase of proportion of dairy animals passing from 62 to 69%, i.e. a growth by 5.53% per year (Faye and Bonnet, 2012). The genetic progress in most of the case is close to zero because the replacement's camels were selected not on the basis of their additive genetic values for growth traits or dairy production, but mainly on their appearance and conformation (Al-Mutairi et al., 2010).

There is an urgent need for setting up record systems of camel performances of the different breeds and types, for establishing proper selection program for the improvement of the productivity. But, it is necessary also to characterize properly the camel biodiversity and to preserve some ecotypes having low herd size or living in specific environment. For example, in Saudi Arabia, camel breed as Adhana limited to mountains area (Faye et al., 2011) or in Pakistan, Raigi breed which have relatively low number of heads but are very well adapted to specific milieu (Raziq et al., 2011). Some breeds or types could have specific physiology which must be deepen for a better understanding of the adaptation process. For example in Niger, it has been stated that the reproductive performances and reproduction cycle was quite different between Manga and Azarghaf testifying an important physiological difference in the ovarian activity (Vias et al., 2006).

Water and feeding management

It is widely reported that camel is well adapted to ecosystems with low nutritive resources and water scarcity. In that sense, camel is regarded as an environmental friendship animal. Indeed, it presents some advantages compared to other ruminants:

- By its ability to stay several days without drinking, it can use rangelands far away from the water points, and then decrease the pressure around them.
- By its feeding behavior, the camel is able to graze a highest variety of plants than the other ruminants leading to a lower pressure on the floristic biodiversity of the arid lands (Rutagwenda et al., 1990)
- By its salt tolerance, the camel is able to eat halophyte plants which are unpalatable for the other herbivorous (Yagil, 1985).
- By its special anatomy (long neck), the camel is able to graze the different strates in the pasture ecosystems, from grass to trees with a limited overgrazing (Faye and Tisserand, 1989).
- By its ambulatory and low gregarious behavior in pasture, the carrying capacity of a camel herd is well distributed in grazing area (Richard, 1985).
- Due to its soft feet devoid of hoof, the walking of a camel herd is less aggressive for the soil than herbivorous with hooves
- Thanks to the longer transit of feeds in the digestive tract of camel, the seeds rejected in the feces could increase their germinating power better than for other ruminants in arid lands (Trabelsi et al., 2012).
- By its digestive physiology (nitrogen recycling, slow transit, ruminal flora,…), the camel can better valorize the poor nutritive feedstuffs and shows a better feeding efficiency than cow, contributing to a better ratio resources/production (Jouany, 2000).

However, the current changes in camel farming systems based on intensification of the management could modify this conception. In Saudi Arabia for example (Abdallah and Faye, 2013), the camel farming systems move from extensive form (Bedouin system based on camel mobility, low inputs, pastoral feeding and low market integration) to semi-intensive or even intensive system (based on feeding by irrigated feedstuffs, settlement and market integration). In such change, the water consumption increased from 3,000 m^3/ha to 35,000 m^3/ha (table 1). The biomass productivity passed from 5 tons to 18 tons of DM/ha. Thus, the water consumption for feeding one camel is multiplied by 3.2 contributing to higher pressure on water resource. The assessment of water consumption per liter of produced milk is multiplied by 9 passing from 938 to 8601 l per liter of produced milk (table 1).

At the national level, based on FAO statistics regarding camel population and considering the changes in the percentage of the different systems since 1961 (Abdallah and Faye, 2013), the water consumption increased approximately from 180,000 m^3 to 280,000 m^3 in Bedouin system while it passed from 7,000 to 860,000 m^3 in intensive system for the last 50 years.

Table 1. Assessment of the water consumption in camel farming systems in Saudi-Arabia

item	Intensive system	Bedouin system
water/ha (m3)*	35000	3000
DM production (kg)	18000	5000
% prot	14	11
Nb camel/ha	4,11	1,14
water/camel (l)	8517	2628
prot/animal/ha (g)	613	482
milk/ha (l)	11,1	8,8
water/milk (l/kg)	8601	938

*This number included only the water irrigation for fodders

Thus, the water demand increased considerably due to the changes in the farm management regarding especially the feeding systems. This aspect has to be taken in account in the near future. The intensification of the camel production is contributing to the pressure on the water resources in spite of ecological advantage of the camel. However, similar estimation has to be done with dairy cattle in similar ecosystem for example, in order to evaluate the potential comparative advantage of camel for sustainable production.

In intensive camel production, the technical model adopted by the farmer for the feeding system is mainly based on irrigated alfalfa plus concentrates like barley and/or wheat bran. The use of agro-food by-products is not often suggested. For example, olive cake which is commonly used in desert sheep diet from countries producing olive was rarely tested in camel. Yet, such by-products could be a partial alternative to the distribution of green forages or cereals obtained by irrigation in a context of very high water constraint contributing to a more sustainable feeding system. It is obvious that alternative ingredients for feeding high-yield camel is a convenient approach for contributing to a better balance between natural resources and camel production. The development of fodder production under salty water irrigation is one of the ways suggested by scientists (Breulmann et al., 2007).

The integration of camel rearing in global sustainable economy

Mainly used in the past as a "desert ship" for the transportation of goods and human, the camel produced also milk, meat and wool which were self-consumed in most of the cases. In consequence, camel rearing was poorly integrated to market. The growing urbanization and the increase of camel products demands from consumers less connected to Bedouin life have precipitated the market development for the camel products, especially milk which was formerly regarded as a gift for the visitors. However, the challenge for sustainable economy is to manage economical development without increasing resource use and environmental impact. This must be done by using strategies and technology that break the link between economic growth and environmental damage. In that sense, camel economy has to minimize the depletion of natural capital. In other word, the increasing integration of camel rearing into market has to take in account the consequences of this development on the environment and social organization of camel production. Of course, the intensification process described in the former chapter, subject to the possibilities for offering low "ecological cost" fodder to selected high-yield camels is clearly a way for increasing the camel productivity, but this intensification has to be linked to the production of high quality products (both in term of organoleptic and hygienic aspects) presenting comfortable added values to the producers.

The camel has obviously good stakes regarding the quality of its products. Camel milk and camel milk products like fermented milk are acknowledged for their dietetic and even medicinal properties (Konuspayeva et al., 2004). The fermented milk as *shubat* (Kazakhstan), *gariss* (Sudan) or *zrig* (Mauritania) are appreciated for their probiotic virtues. Camel meat is also provided high quality protein with low cholesterol content to the consumers (Kadim et al., 2008). Moreover, considerable efforts have been done for proposing new milk and meat products (Farah and Fisher, 2004). Due to the supposed or proved properties of the camel products, their prices on the market are generally high. The camel productions appear rather profitable, although the hygienic conditions could be improved in many cases (Eberlein, 2007).

In several countries, camel dairy plants were implemented contributing to the emerging of powerful value chain leading to a rational organization of camel milk producers, the integration of camel sector in the national livestock economy, and the development of a distributors' network (Abeiderrahmane, 1997). In Central Asia and in Middle-East, fermented and pasteurized camel milk is available in supermarket as well as the camel meat.
Contrary to milk, the camel meat market is regional and lead to important flow of live camel stock, especially from the Sub-Saharan countries and Horn of Africa to northern Africa and Arabian Peninsula (Aklilu and Catley, 2011). So the pattern for camel meat economy appears different than for milk which remains integrated into local market. The camel meat represents 0.13% of the total meat consumed in the world and 0.45% of the herbivorous meat only. However the growth of camel meat production is higher than cattle meat but comparable to buffalo meat. The camel meat production was multiplied by 2.90 between 1961 and 2009 corresponding to annual growth of 3.5 % that is higher than the camel population growth. The sustainability of such market is depending on 2 main aspects: the security and the health constraints. The camel stock market for export is widely "informal" (no official declaration) and if the commodity channel is well organized, the economical importance of this market is not well known (Alary and Faye, 2009). This lack of official implementation contributes to the insecurity all along the trade routes, especially in countries where local conflicts occur (especially in the Horn of Africa). Regarding health aspect; disease is of particular concern when camels are forced to live outside of their natural habitat. In many countries, the veterinary services are poorly adapted to camel diseases prevention. Mange, plant poisoning or tick infestations are common. Emerging diseases provoking high mortality are also regularly described (Faye et al., 2012; Roger et al., 2000). Because the increase of risk of transboundary diseases in camel, the World Animal Health Organization (OIE) in Paris has implemented one *ad-hoc* group of experts on camel diseases for establishing rules and standards (nomenclature of diseases, diagnosis kits, references lab,…).
One important point regarding the sustainable camel economy is to integrate (i) ecosystem services offer by the camel farming systems, in one hand, and (ii) negative "externalities" of the camel farming activities on the environment, in another hand. In order to promote "sustainable business practices", the price of the products and the taxes on the trade should include those aspects.

The social dimension of the camel in the desert societies

The social role of camel in the Bedouin way of life and beyond in all the pastoralists' societies from Africa, Central Asia and Middle-East is widely underlined by the anthropologists. As for other livestock in low input systems, camel is an element of the social prestige of the owners, a capital for ensuring the well-being of their family, and, due its remarkable resistance to drought, a security face to the climatic changes as it was observed in Sahelian countries (Faye et al., 2012). Its role in the securization of the pastoralists systems is making happen by the switch from cattle to camel in farming systems confronted to the aridification of the milieu, even among traditional cattle breeders like *Wodaâbe* in Niger or *Massaï* in Kenya (Potkanski, 1999). Because, its longevity and its low reproductive performances compared to small ruminants rather regarded as "coin purse", the camel is really the long-term capital for the mobile family. From this point of view, it contributes strongly to the poverty alleviation by (i) the food security (it can provide milk and meat for self consumption), (ii) the securization of the long-term capital, (iii) the contribution to the diversification of the incomes in livestock systems including a multi-activity of the family, (iv) the ability to be included in market economy at local or regional level, (v) the contribution to solidarity network among the pastoralists (Faye, 2009).
Moreover, the "traditional life" in the desert is regarded as a "harmonious, symbiotic relationship with the environment" (Breulmann et al., 2007), the pastoralists managing their fragile rangelands without over-exploiting them (Olsvig-Whittaker et al., 2006). This proximity to the nature including the emotional links with the camels could be maintained in spite of the changes in the farming systems described above. In spite of the new standard of life developed in Middle-East, the search for the quality of life, by passing for example the week-end under the Bedouin tent surrounded by the camel herd, is still expected by the recently urbanized people. The challenge of the new camel farming systems based on the intensification of the management and production would be to maintain this relationship.

Conclusion

The challenges of the camel farming for a sustainable development are not necessary specific to camel. But, as camel is specifically, "the animal of the desert", there is a special responsibility for the camel stakeholders, producers, decision-makers, or scientists. Face to the camel demography growth at world level, a better balance with the carrying capacity has to be reached by the intensification of the camel management while respecting the biodiversity and water resources. New camel farming systems have to propose products with high added values, both in term of quality and of economical interest for a market more and more sensitive to the ecological conditions of production.

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